DOCUMENT RESUME

ED 258 815 SE 045 811

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TITLE	Solar Water Heater Systems for Building Trades Class.
INSTITUTION	Tennessee State Univ., Nashville. Div. of Continuing Education.
SPONS AGENCY	Department of Energy, Washington, D.C.
PUB DATE	Nov 82
NOTE	45p.; Several pages contain marginally legible print. Requirements for Energy Workshop, Tennessee State University.
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	*Alternative Energy Sources; Energy; *Energy Education; *Heating; Science Activities; Science Curriculum; Science Education; Science Instruction; Secondary Education; Secondary School Science; *Solar Energy; *Vocational Education
IDENTIFIERS	*Solar Heaters

ABSTRACT

This teaching unit serves as a guide for the installation of active solar water heating systems. It contains a project designed for use with secondary level students of a building trades class. Students typically would meet 2 to 3 hours per day and would be able to complete the activity within a 1-week time period. Objectives of this unit include: (1) analysis of direct solar energy; (2) assessment of the benefits and disadvantages of solar energy use; (3) on-site examinations of solar water heater systems; and (4) hands-on installation of solar heating systems. Experiments which develop basic principles of solar energy are outlined for student investigation. Suggested strategies, materials, procedures and background information are provided for each exercise. The unit also contains several illustrations that indicate the materials and procedures that are needed for installation of a solar heating system. Additional resource materials are listed and a bibliography is included. (ML)

SOLAR

WATER HEATER SYSTEMS

FOR

BUILDING TRADES CLASS

ENERGY
WORKSHOP

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Tennessee State Unitversity

November 1982

The Energy Workshop was co-sponsored by TSU and a grant from the U.S. Department of Energy. However, the opinions and positions expressed in this document are those of the authors and do not represent the official opinions, policies of the sponsors.

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INTRODUCTION:

This unit was compiled for use in a building trades class to provide instructional preparation for installation of an active solar water heating system in Middle Tennessee. The building trades class is comprised of students in grades 9-12 who are in the class for 2 to 3 hours per day. One week should be sufficient time for this study unit. Hands-on installation would be integrated with the class project of building a house and installation done during the proper sequence of the project. Evaluation of the completed work may be done near the end of the building trades class project.

OBJECTIVES:

1. Student to understand direct solar energy
2. Student will distinguish between passive and active solar energy
3. Student will discuss cost considerations
4. Student will determine certain advantages and disadvantages of solar energy
5. Student will analyze flat plate collectors
6. Student will examine solar water heater systems on site
7. Student will have hands-on experience during installation of solar water heating system

ACTIVITIES

Lesson 1

1. Set up experiments (allow one hour).
2. Have students list energy products they use daily
   Discussion: What would student's lifestyle be like without these energy products?
3. Discuss topics relative to building project:
   Solar energy
   Active solar water heating system
   Cost determination
4. Evaluate experiments

Lesson 2

1. Film (allow about 30 minutes)
   Suggestions: "How to Build a Solar Heater" or "Here Comes the Sun"
2. Discussion:
   Flat plate collectors
   Location of collectors
   Back-up requirements
3. Students are to draw a similation of the flat plate collector
4. Discuss materials needed for a flat plate collector

Lesson 3

1. Field trip: visit a local home with solar water heating system (1 1/2 hour)
2. Use resource person for information and discussion (Suggestion: a local contractor who has installed solar water heating system.)

Lesson 4

1. Field trip: visit a solar home (Suggestion: solar home built by building trades class, Cheatham County High School, Ashland City.)

Lesson 5

1. Students to familiarize themselves with drawings of water heating system. Study the specifications of one being installed. (Suggestion: Solarcraft Automatic Sun-Powered Water Heater by State Industries, Inc., with manual of installation, operation, and maintenance.
2. Visit the site of the project

Lesson 6

1. Written examination and evaluation of work

SOLAR ENERGY

Solar energy, defined, is simply energy received by the earth from the sun.

If you ever stepped barefoot on a hot pavement on a July afternoon, you might have exclaimed: "Whew! You could fry an egg on this pavement!" You indicated then what solar energy is all about. Heat generated by the sun would melt a sphere of ice the size of the earth in 16.6 minutes. While only a small portion of that energy is intercepted by the earth, there is still enough to provide 646,000 horsepower for every square mile of surface.[1]

From earliest history people have been trying to capture and use the enormous reservoir of free solar power. The Greeks designed houses around central sun-gathering courtyards 3,000 years ago. Before America became a nation, Indians of the Southwest built their cliff pueblos to trap the warmth of the winter sun. During colonial times, homes were built with stove warmed kitchens on the north side so that living areas would have sunny south walls.[2]

ACTIVE AND PASSIVE SOLAR HEATING

There are two basic types of solar heating systems: active and passive. Active systems use liquid or air to absorb and transfer the heat to its destination. They require pumps and piping or fans and ducts to do the job but are relatively easy to install in existing buildings as well as new ones. An active system is the type most often used when an older home is being remodeled and upgraded with solar energy features.[3]

Passive solar systems are sometimes referred to as the soft approach because they require little in the way of hardware and let nature do most of the work. The solar features are part of the house rather than a collection of accessories. Passive systems do not need pumps, blowers, or plumbing and usually have no problems of leakage or winter freeze-up. Instead, they use large heat-absorbing masses, such as concrete walls and water-filled drums, to trap solar heat as it passes

through south-facing windows. Heat transfer can be by na ıral radiation and convection, or warmed air can be channele where it is needed with the help of vanes, fans, dampeıs, nd blowers. Because a passive system is a basic element of the house itself, it works best when it is planned in advance as part of a new construction rather than being added to an existing nonsolar home.[4]

Greenhouses are among the oldest and most familiar solar heating devices, but because they warm vegetables and flowers rather than men and women, most people do not think of them as replacements for a conventional home heating device. However, what warms a plant can also warm a house, and lean-to greenhouses are being used more and more as passive solar collectors in homes with unobstructed south walls.[5]

Functional solar systems were providing domestic hot water in 30 percent of the homes in Pasadena, California before 1900 and by 1940 Miami, Florida had 60,000 of them. Heating water in the family home is one of the most advanced applications of solar energy both here and abroad.[6] In Tennessee, as throughout the south, when solar energy is used, it is generally used to heat domestic hot water and as a secondary source of home heat.

CONSIDERING THE COST

Solar powered hot water systems are the most practical way for the average homeowner to take advantage of the sun's energy. They are easier to build and less expensive than complete solar home heating units. Since there is year-round need for hot water, maximum use can be made of available sunlight. Various designs are available which have been developed to accomodate diverse conditions of weather, sunlight, and the amount of hot water needed by the user.[7]

Before investing in solar space heat or solar heated

domestic water systems, an analysis of heating loads, site location, fuel consumption, house size, thermal efficiency, government tax incentives, and other variables is needed to make an appraisal to determine if solar energy is for you.[8]

Solar water heaters have long been competitive with electricity, fuel oil, and natural gas in many parts of the country. Solar space heat is usually competitive wherever there is moderate to high solar radiation. Even in low radiation locales, solar home heating can be a money saver if fuel and utility costs are high.[9]

Generally, solar heating makes good economical sense if it pays for itself within 10 years. In other words, your 10-year savings in home fuel consumption should equal or exceed the cost of installing a solar system. Usually, solar heating will provide the biggest savings in homes with high fuel bills: if the fuel bill runs more than $3,000 a year, a $15,000 solar system can be paid for, amortized, in 10 years by cutting fuel bills in half; but if the fuel bill is $500, it is doubtful that solar heating will pay.[10]

Solar energy is an inflation proof fuel service since the sun's energy is free. With a solar hot water system, the annual electric water heating portion of your electric bill may be reduced up to 80 percent in the Middle Tennessee area. This reduction will help to offset the monthly payments on the solar system and provide a savings in the years ahead as electric costs rise.[11]

With the rapidly increasing fuel costs for all forms of conventional energy and our country's recent unwise over-dependency on foreign fuel supplies, the solar water heater has become one practical way to help reduce long term costs of heating hot water.

TVA has encouraged the installation of solar water heating systems by arranging for low interest loans to be made available

for purchasing TVA approved solar systems. If enough solar water heaters can be used, this will help "hold down" future electrical rate increases by TVA. Not only would there be a savings on the monthly electric bills, but individuals may claim energy credits on their income tax return based on the cost of the solar system installed.[12]

In the past, the cost of installing a solar water heating system was in the $2,000 to $3,000 range.[13] Cost of installation will depend upon several factors: the size of the collector needed, whether the system is an auxiliary to the present system, who does the installation, etc.

The two-fold purpose the consumer has for installing a solar domestic hot water system is to conserve energy and reduce utility bills. In addition to the savings on the monthly electric bills, individuals may claim energy credits on their income tax return.[14]

Cost to the consumer would be the initial investment of a system, and its maintenance. Initial cost would include labor, the collector, plumbing and electrical equipment, and supplies. Many consumers choose to arrange a loan to cover the cost of the initial installation.

ADVANTAGES AND DISADVANTAGES

Although solar energy is plentiful, there are certain disadvantages. One is that the sun's energy is spread thinly. Assuming the solar radiation on a clear day is 100 percent, a hazy day will allow 60 to 80 percent solar radiation, and a cloudy day will allow 5 to 50 percent solar radiation.[15]

Another disadvantage is that the sun's energy is intermittent. It can be reduced by clouds, and also it is only present for about twelve hours per day depending upon the geographical location and time of year.[16]

Generally, the advantage of using solar energy is that it is free except for the initial investment and maintenance.

The sun's energy will never run out. Solar energy is environmentally attractive because little waste is generated in its use. Also, solar energy for residential use does not need to be transported to the site for consumption.[17]

FLAT PLATE COLLECTORS

The main component of the solar hot water heating system is the collector. There are three basic types of collectors: vacuum, focusing, and flat plate.

Because the flat plate collector is the most economic, we have chosen it to install in the house built by the building trades class. Simply stated, a flat plate collector is an insulated, weathertight, box with a clear cover designed to trap sunlight and in which is a dark absorber plate.

As indicated, there are three basic parts to the flat plate collector: (1) an insulated housing, (2) a transparent cover or covers made of glass, glass fiber or plastic and (3) an absorber plate made of aluminum, cloth, copper, glass fiber, iron, plastic, or screening. The absorber soaks up heat from sunlight that passes through the cover and then gives it up to a heat absorber. This fluid, which may be water, anti-freeze, or air, delivers its heat directly or indirectly to water stored in an insulated tank.[18]

LOCATION OF THE COLLECTOR

The location of the collector is important in that it must be on the south side so that plenty of sunshine falls onto its collection surface. True south can be determined by checking the north-south shadow cast at solar noon by a stick set into the ground. Solar noon occurs exactly midway between sunrise and sunset and could be at 1:16 P.M. rather than clock-time. A location should be chosen on the south side with the least possibility of shading or obstruction to the sunlight.

Many solar collectors are mounted on the rooftop. However, the thing to remember is that the collector is a light

trap, collecting light from the sun. On the roof it will receive direct radiation and diffuse sky radiation. A collector mounted at ground level will get both the direct and the diffuse inputs that a rooftop will, but in addition, it will receive reflected energy from the ground: solar energy that is bouncing into the collector off the grass, the snow, neighboring buildings, etc.[19]

COMMON TYPES OF SYSTEMS

All solar water heating systems can be termed either direct or indirect, depending on whether household water is heated directly in the collector or picks up the sun's heat indirectly. In direct systems, open-loop, the fluid heated in the collectors is plain water, which flows directly to the faucet or washing machine. . In indirect, closed-loop, systems, the heat transfer fluid is treated water, air, or some non-freezing liquid, like anti-freeze liquid or a special oil. The heat it picks up from the absorber plate is passed along to the house water through a heat exchanger such as a coil inside or wrapped around the storage unit.[20]

BACKUP REQUIREMENTS

Theoretically, it is possible to put together a solar water system that will completely supply your hot water needs no matter where you live. In practice, however, this would prove uneconomical because of the amount of solar collector area required to achieve that goal. The solution for most families, is a system which produces a large percentage of their hot water needs, the rest being supplies by a conventional backup heater.[21]

Also, solar heat probably won't be able to maintain your domestic water at required temperatures throughout the day or throughout the year. Cloudiness, darkness, and domestic consumption of hot water are the variables. The storage tank

compensates for these variables by building up a supply of heated water. But the tank needs backup during long winter nights and during long cloudy spells in all seasons. The support can come from electric or fuel-burning systems that turn on as needed. Simple on-off controls, activated by heat, turn the backup on when the water temperature drops below a preset level and off when solar energy raises the water sufficiently.[22]

The standard support system works this way:

1. Cold water from the water main enters the storage tank as needed to replace water tapped for domestic use.

2. The solar-collector system heats the water to the required temperature and maintains that temperature as best it can.

3. From the storage tank, water is [illegible]ted to the regular water heating equipment. As long as the water is hot enough, it merely travels through the tank and into domestic use.

4. If the water from the solar-heated tank enters the tank of the backup heater at the temperature below that required, the heater automatically comes on. Relatively little fuel is used, since the heater receives water that is at least partly heated at all times.

5. When the demand tapers off or the solar heat increases, water in the solar storage tank becomes hotter. At the required temperature, the backup system will automatically shut off, returning the entire heating job to the solar-heated part of the system.[23]

Solar Energy 7

Question
How much hotter does a house g[illegible]t when the windows face south instead of north?

Time
One hour

Objective
The student will compare the amount of solar heat collected in south and north windows.

Process Skills
Identifying and controlling variables, measuring, recording and analyzing data.

Materials & Procedure Clues
If you precut the cardboard, it will eliminate the need for younger children to use a knife.

[illegible]cept
[illegible]ioned correctly, it can be used as a passive solar collector.

Background

When building or buying a home, taking advantage of solar energy through the proper placement of the house on the lot and the use of windows can help keep down utility bills. The house should be [illegible] so that the length runs east and west. Most windows should be placed on the south wall [illegible] windows should be placed on the other walls. A roof overhang, which controls the [illegible]ed, should extend far enough to keep the sun from shining in the windows [illegible] summertime, but not too far so the sunlight can enter the house in the winter. Double[illegible] windows will help the house retain the absorbed heat. The number of windows and the size of the overhang has to be adjusted for the climate. Deciduous tress can be used to shade the house in the summer and to allow the sun to heat the house when they lose their leaves in winter.

Precautions
A knife has to be used to cut the boxes.

Results
The box with the window facing south will be ab[illegible] than the other box

Strategies
Before: Ask the students to predict which box will get hotter.

After: Discuss the summary question.
Ask the students to predict what would happen if the activity were tried at other times of the day or on a cloudy day.

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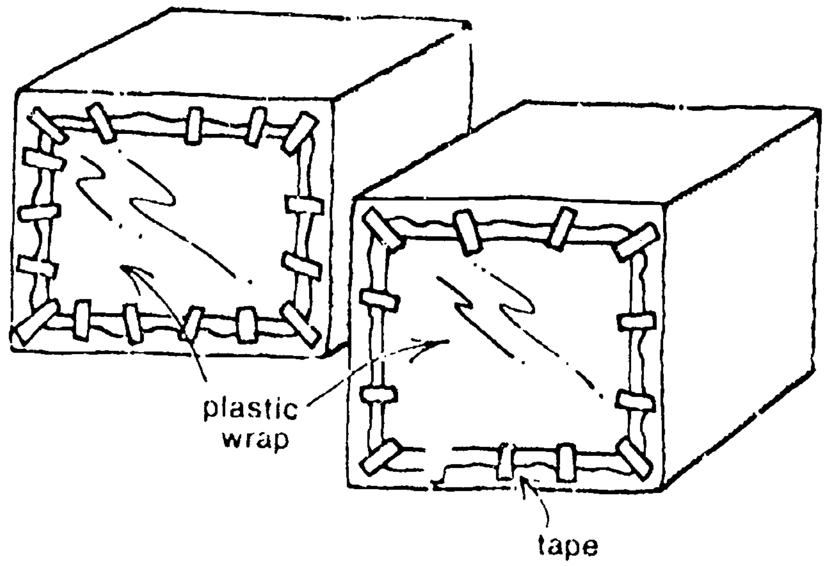
HOW MUCH HOTTER DOES A HOUSE GET WHEN THE WINDOWS FACE SOUTH INSTEAD OF NORTH?

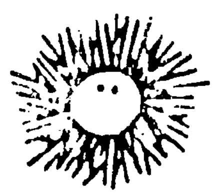
7

MATERIALS:

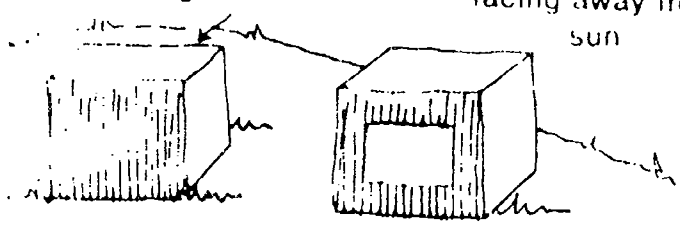
2 Cardboard boxes (same size)
White paint or paper
2 Thermometers
Plastic wrap; knife ◀ Teacher's Discretion
Masking tape



Cut a large hole in 1 side of both boxes.
Cover holes with plastic wrap.
Tape the wrap tightly over the holes.



Paint both boxes white, or cover them both with white paper.



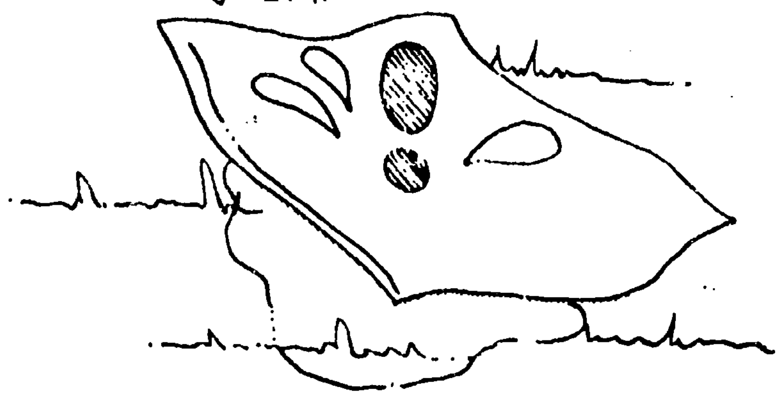
Place a thermometer in each box. Record the temperature in each box, and put them in the sun.

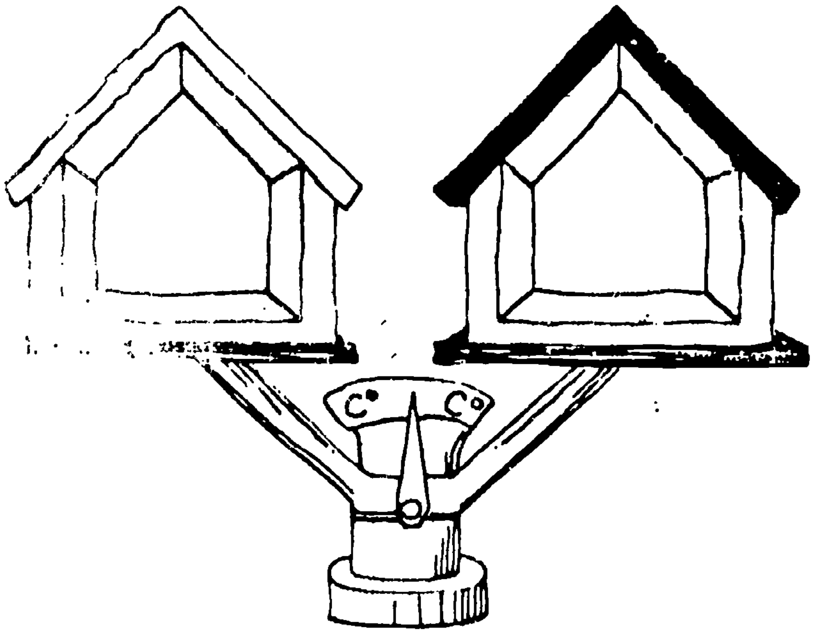
Record the temperatures after 10 minutes, 20 minutes, and 30 minutes. What did you find?

Time:	Start	10 min.	20 min.	30 min.
facing sun				
facing away from sun				

Would you get the same results if the paper were on top of the ice cubes?

Does it work faster with the paper on the top or on the bottom?

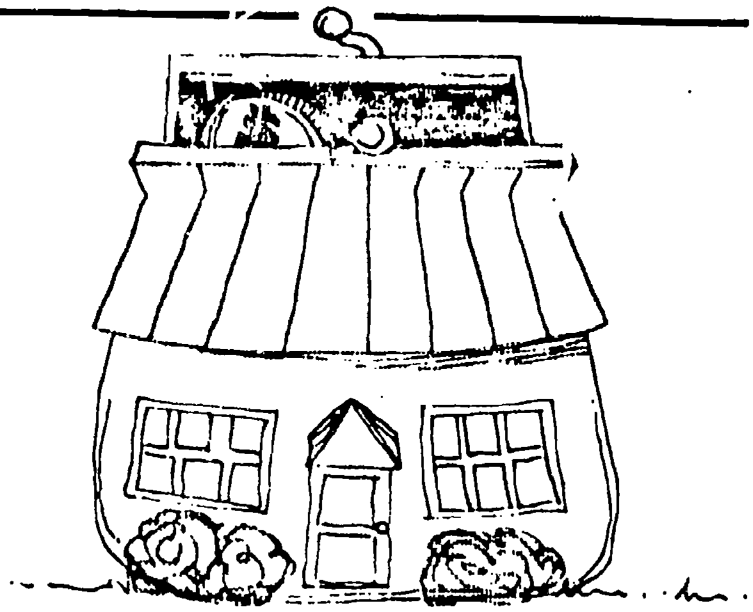




Summary question:

Would a house with a white roof be cooler than a house with a dark roof?

OTHER IDEAS TO EXPLORE:



Would a house with a dark roof be more or less expensive to air-condition in the summertime?

Solar Energy 8

Question

What color absorbs the sun's heat best?

Time

Forty-five minutes

Objective

The student will compare different colors' ability to absorb heat.

Process Skills

Identifying and controlling variables, measuring, and inferring.

Materials & Procedure Clues

Other colors of construction paper can be used. Be sure you have both light and dark colors for the students to try.

Concept

Different colors absorb different amounts of solar energy.

Background

Dark colors absorb heat much better than light colors, but they also tend to reradiate the heat. This fact has a practical application—choosing a roof or house color. For example, in warm climates, a light colored roof can keep houses cooler.

The reason black absorbs heat best is that it soaks up most of the sun's rays. White reflects most of the light that strikes it.

Precautions

None

Results

[illegible] will melt fastest on dark colors

Strategies

Before: Ask students to predict which color will melt an ice cube first.

After: Discuss the summary question.
Students may get varying results. Ask them to try to give reasons for this.

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WHAT COLOR ABSORBS THE SUN'S HEAT BEST?

8

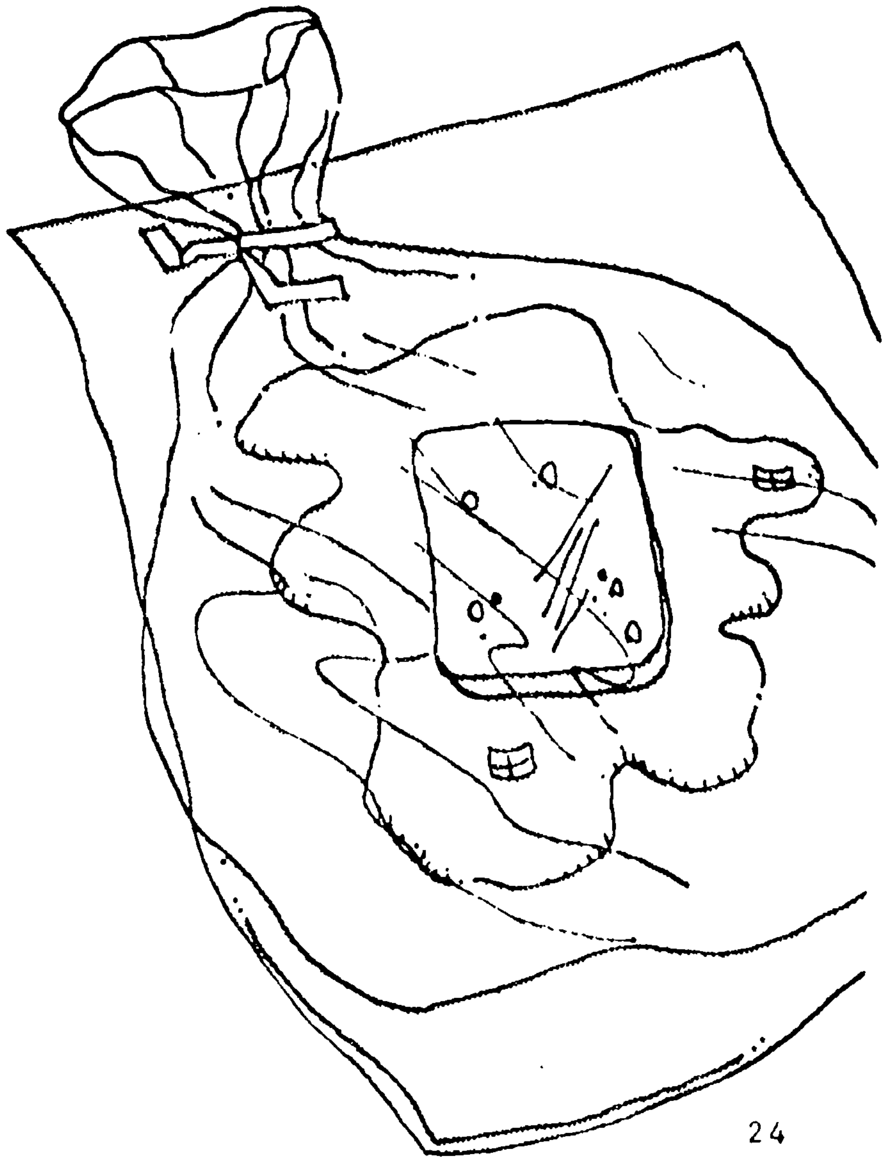
MATERIALS:

White, black, green, red, and blue construction paper, all the same size
Timer
Uniformly-sized ice cubes
Plastic bags (sandwich size)
Metric measuring cup

Put an ice cube in a bag. Place a separate cube on top of each sheet of construction paper. Which cube melts first?

After 20 minutes, measure the amount of water collected in each bag.

colors of paper	amount of water collected



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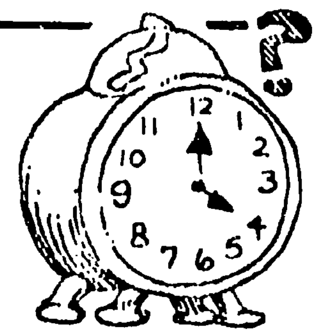
Summary question:

If you were designing a house in Alaska, on which side would you have the most windows? What about a house in Arizona?

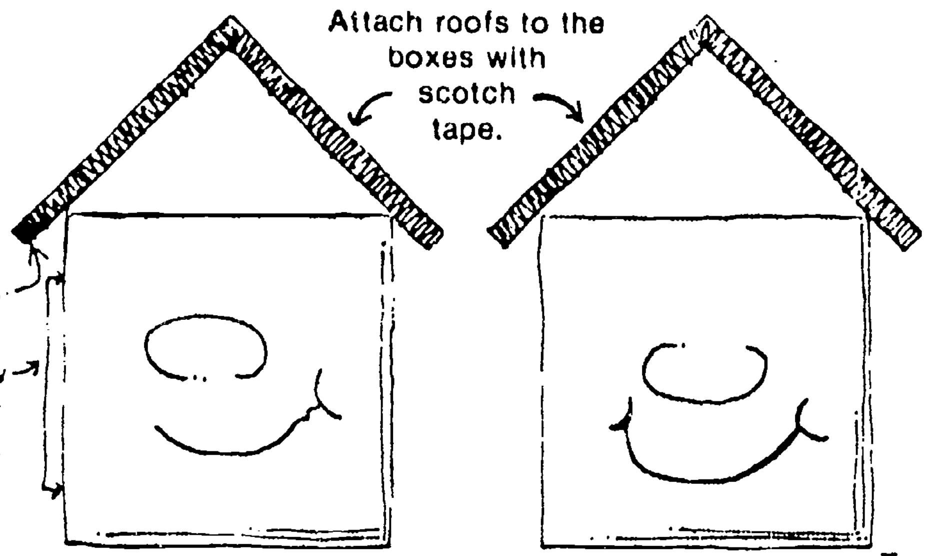
OTHER IDEAS TO EXPLORE:



Try this experiment at different times during the day.

Does the time make any difference?

Add an overhang to both boxes.



Does this make any difference?
How would the overhang affect the experiment at different times of the year?

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Solar Energy 11

Question
Which material stores solar energy best?

Process Skills
Identifying and controlling variables, measuring, and inferring.

Time
One hour

Materials & Procedure Clues
Painting the box beforehand will save time.
A warm, sunny day will yield best results—too much heat is lost on a cold day.

Objective
The student will compare the heat storage abilities of different substances.

Concept
Materials will retain heat differently based on their specific heat values.

Background
One of the biggest problems of making widespread use of solar energy is finding ways to store it when the direct sunlight is not present. Different substances hold heat more efficiently than others. Besides water, substances such as pebbles, air, and Glauber's salt (phase-change) are used to store heat collected from the sun. Storing solar heat is one of the more expensive aspects of a solar heating system for a home. This is the reason why a combination solar and conventional heating system is often more economical and practical. Solar heating systems for swimming pools are extremely practical since the swimming pool acts as its own storage system. The material with the highest specific heat will retain the most heat. Water which has a high specific heat compared to most materials, is the standard. The specific heat of water is 1, while the specific hear of sand is 0.2. This means that water will retain 5 times (1/0.2) as much heat as an equal weight of sand.

Precautions
Thermometers are broken easily, so urge careful handling.

Strategies
Before: Ask the students to predict which material will hold heat longest.

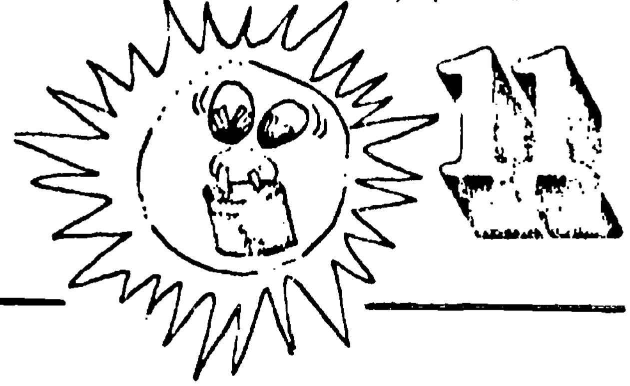
After: Discuss the summary question.

Discuss the application of this concept to building a solar energy collector.

Results
Water should retain heat longest, then sand [illegible]

24

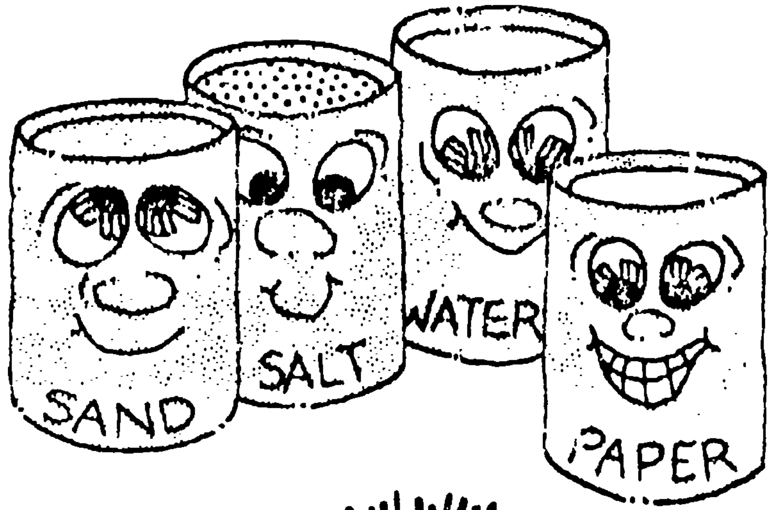
WHICH MATERIAL STORES SOLAR ENERGY BEST?

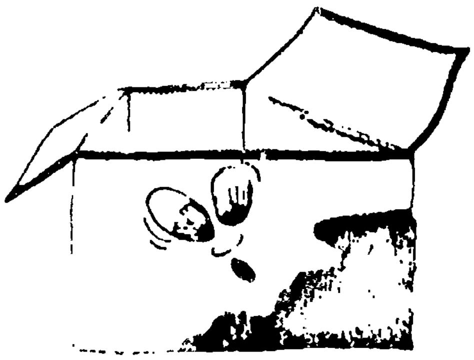


MATERIALS:

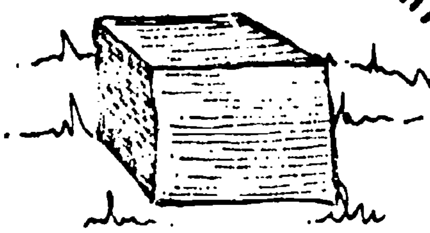
Cardboard box
Black paint
4 Small metal cans
4 Thermometers
Sand, salt, water, and torn-up pap

Fill each can with a different material.





Paint the box black.

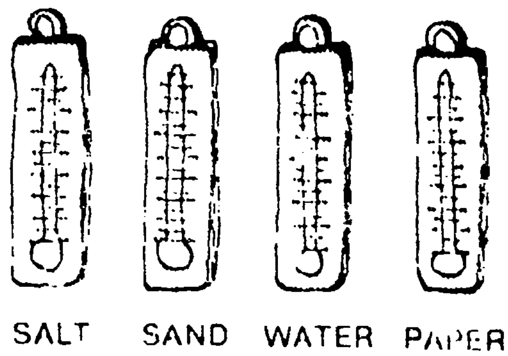


Place the box in the sun.

Put the cans in the box, close it, and leave it for ½ hour.

Now remove the cans.

Place a thermometer in each can.



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Watch the temperatures fall, and record them below. Stir occasionally. Which temperature falls the slowest?

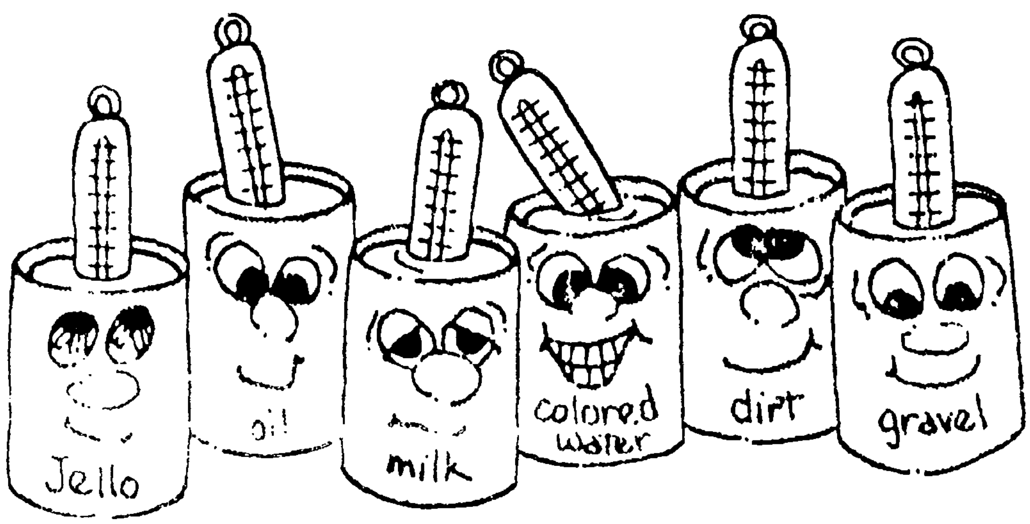
	2 min	4 min	6 min	8 min	10 min
salt					
sand					
water					
paper					

Summary question:

Which material stores solar heat best?

OTHER IDEAS TO EXPLORE:

Try some other materials like Jello, oil, milk, colored water, dirt, gravel, or styrofoam chips. Before you test them, can you predict which one will hold heat best? Can you think of other materials to try?



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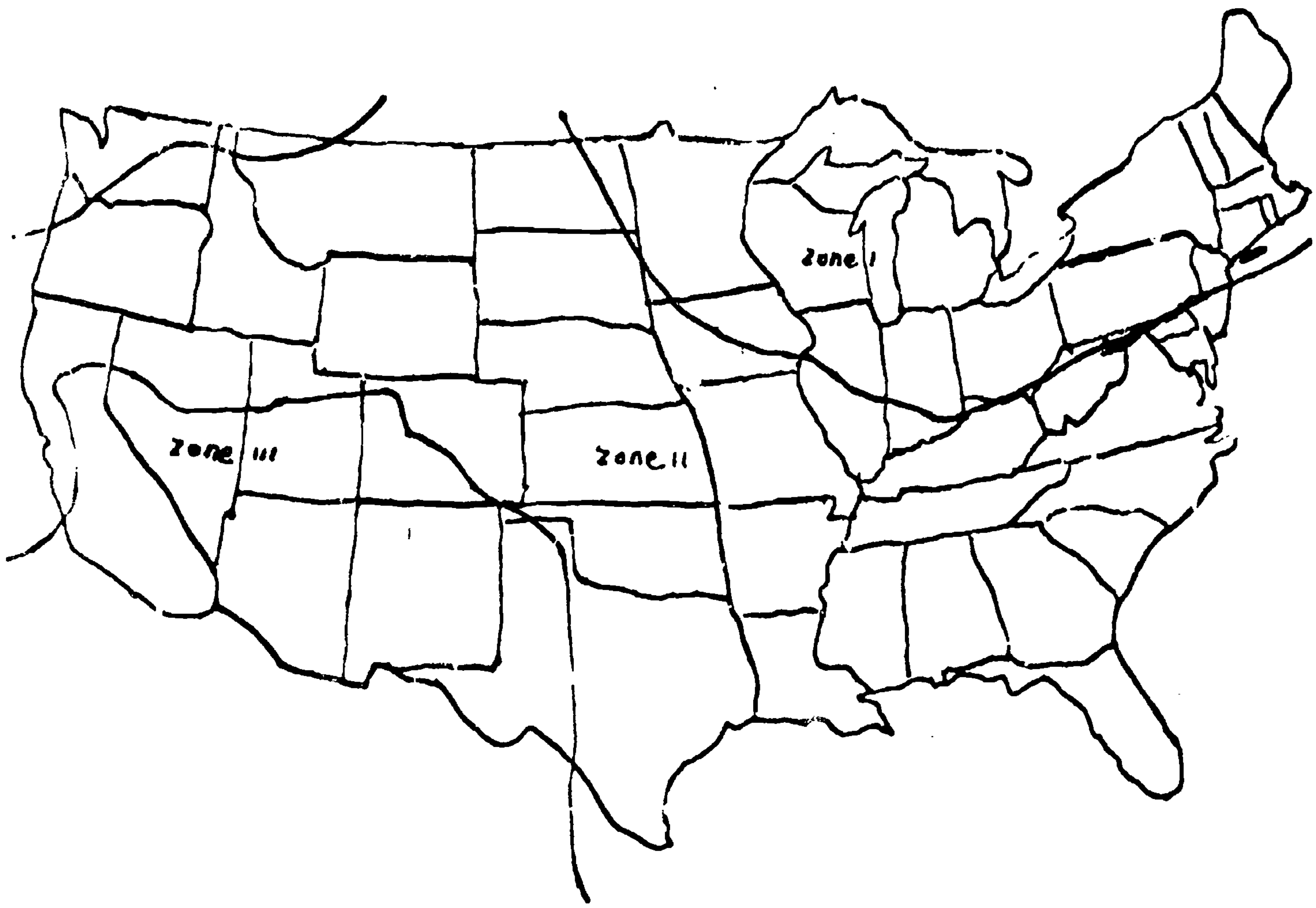
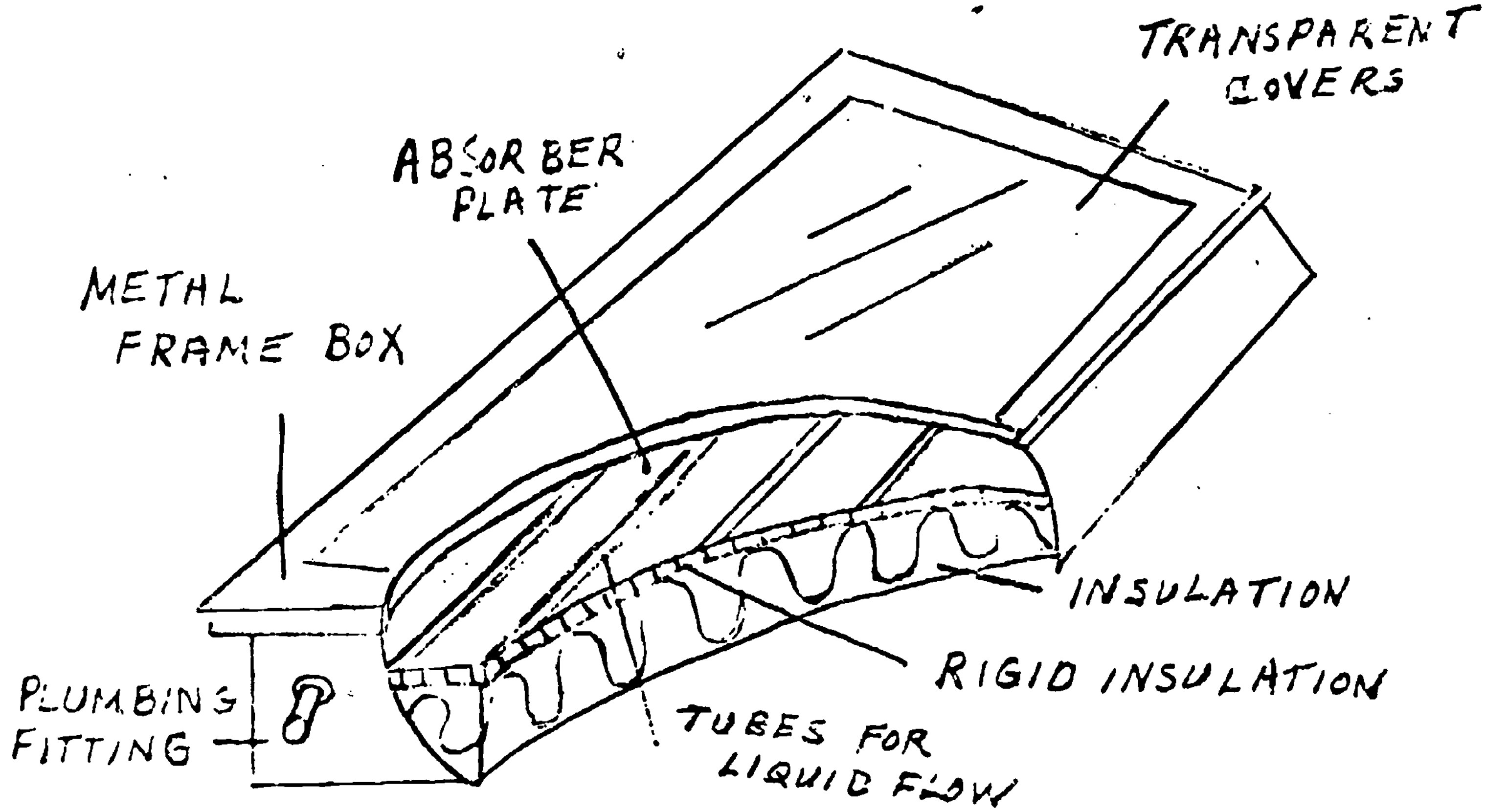
SOLAR RADIATION IN THE UNITED STATES



ZONE I	LOWER SOLAR RADIATION
ZONE II	MODERATE SOLAR RADIATION
ZONE III	HIGH SOLAR RADIATION[25]



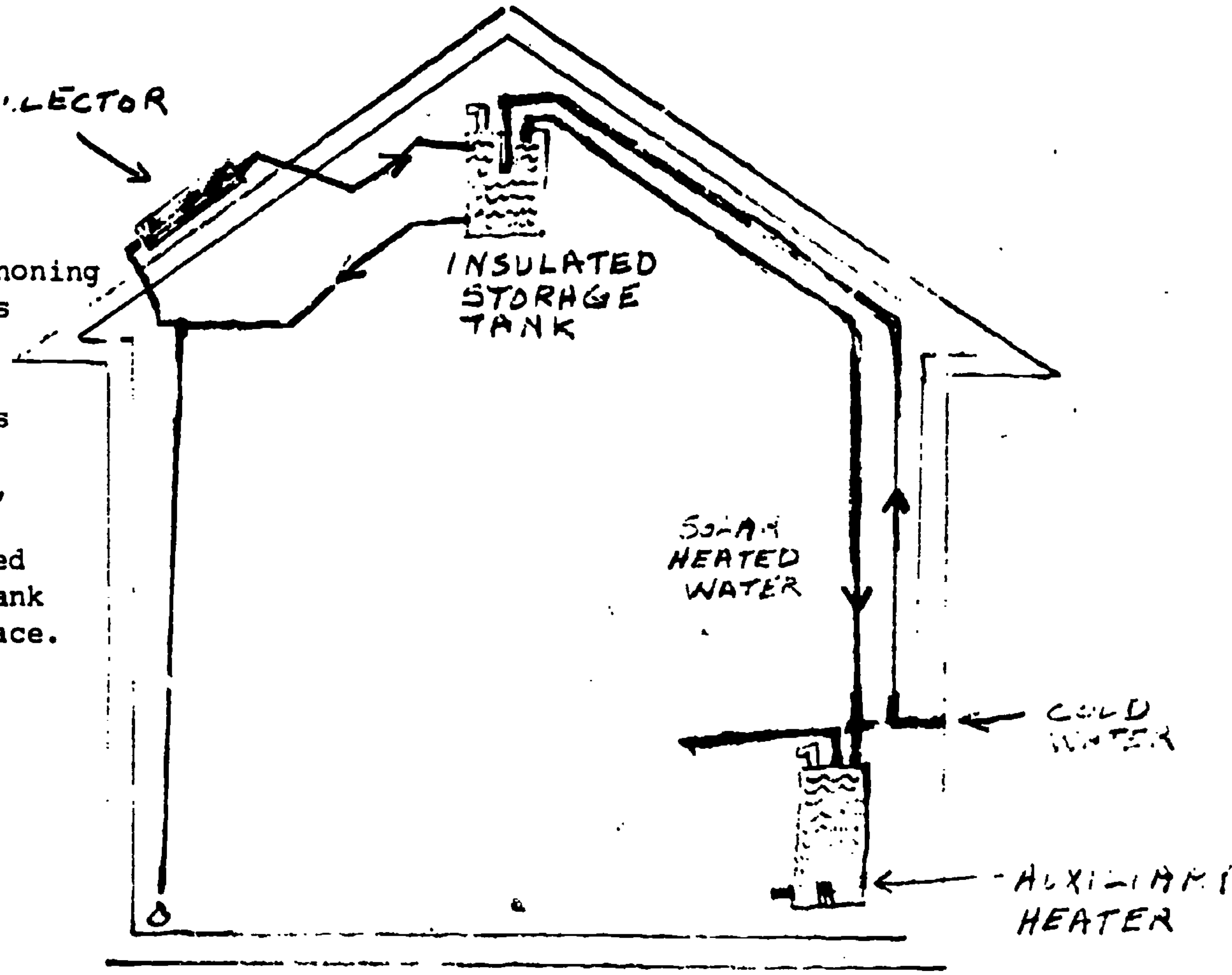
FLAT PLATE SOLAR COLLECTOR[26]

Solar, p.21

Direct (Open-Loop) Systems

<u>Thermosiphoning</u>. The simplest direct system is the thermosiphoning water heater. Water circulates by natural convection and gravity, rising and falling in response to solar heat, just as air would. As long as the absorber keeps collecting heat, water warmed in the collector rises into a storage tank placed slightly above, while cooler tank water runs down to take its place.

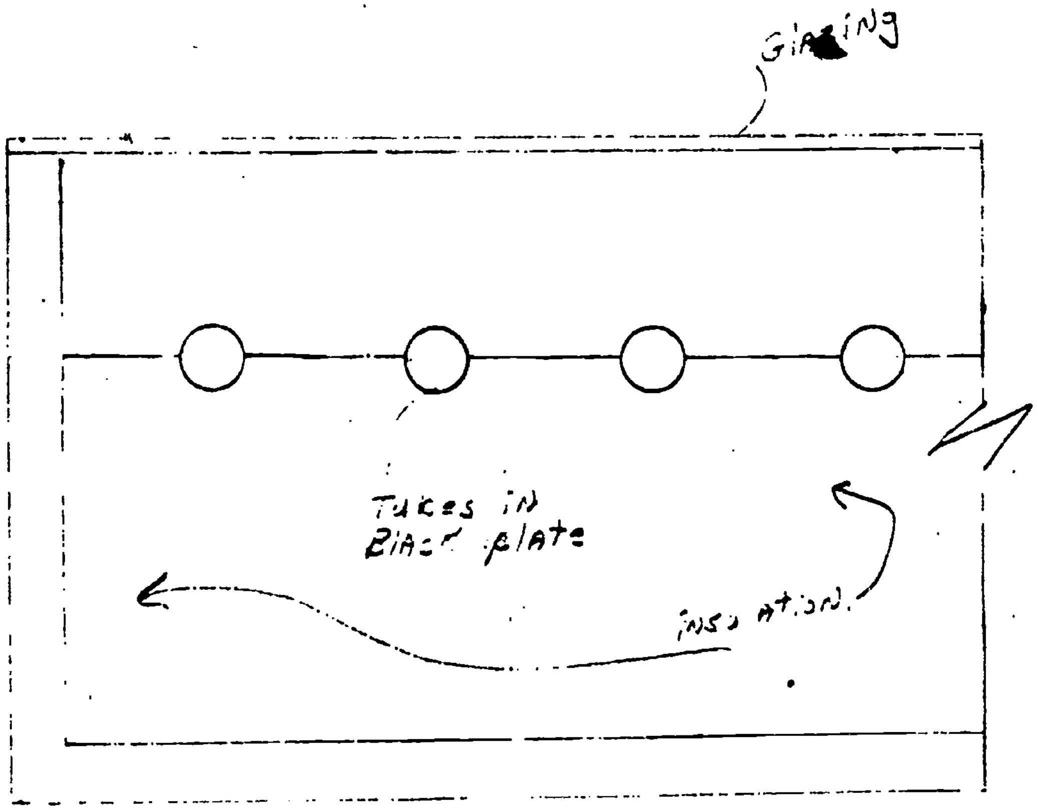
In a thermosiphoning system, cold water flows from the bottom of the tank to the bottom of the collector, and returns to the tank when warmed.



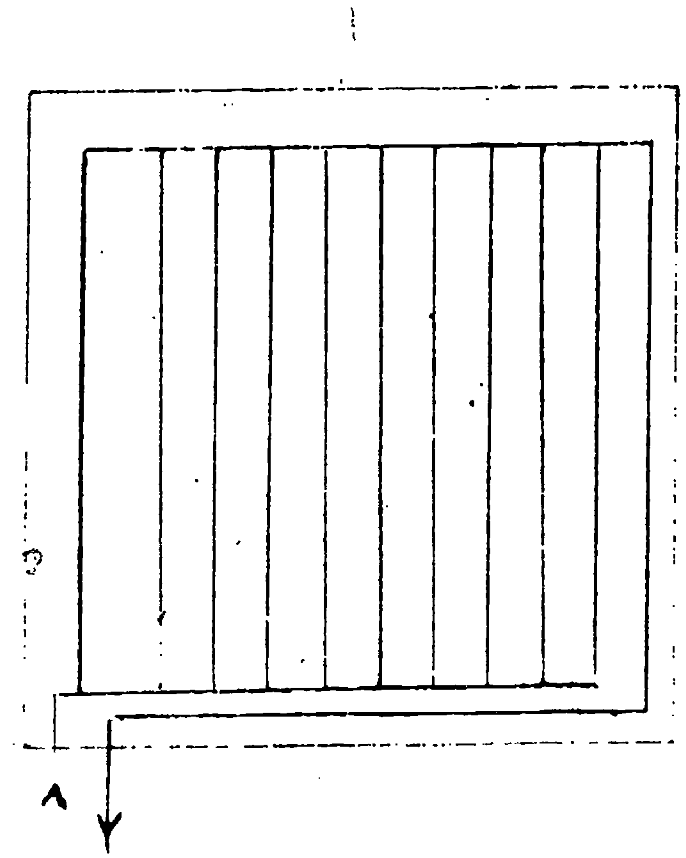
THERMOSIPHONING

These drawings show the basic structure of a solar collector using a liquid. The tubes, bonded to a black plate, pick up the heat and transfer it to the liquid.

The tubes are laid out in a pattern that allows the liquid to flow in, across the black plate, and out of the collector into service, thereby heating space or water.

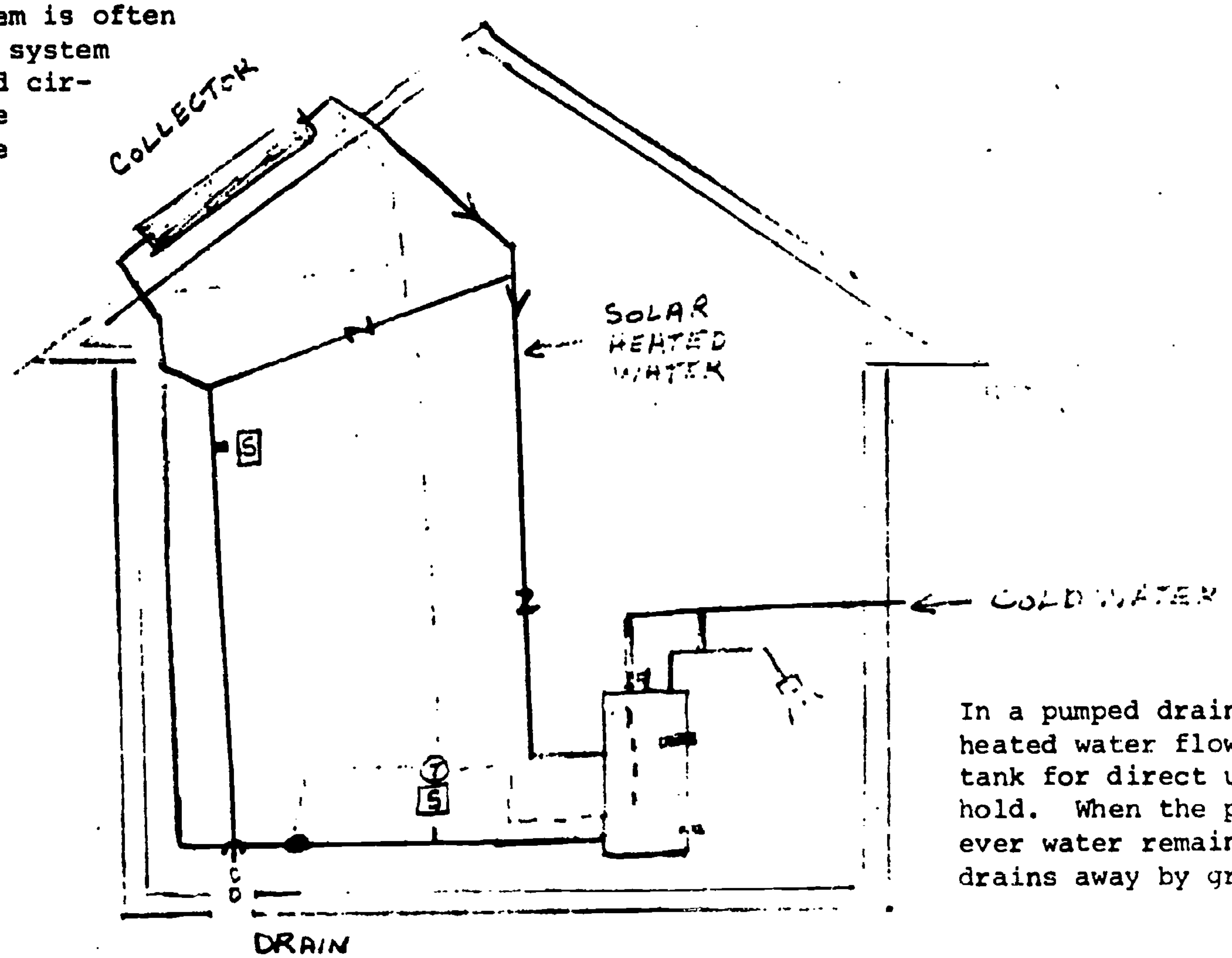


A-A Section Thru solar collector



Plan view of solar collector

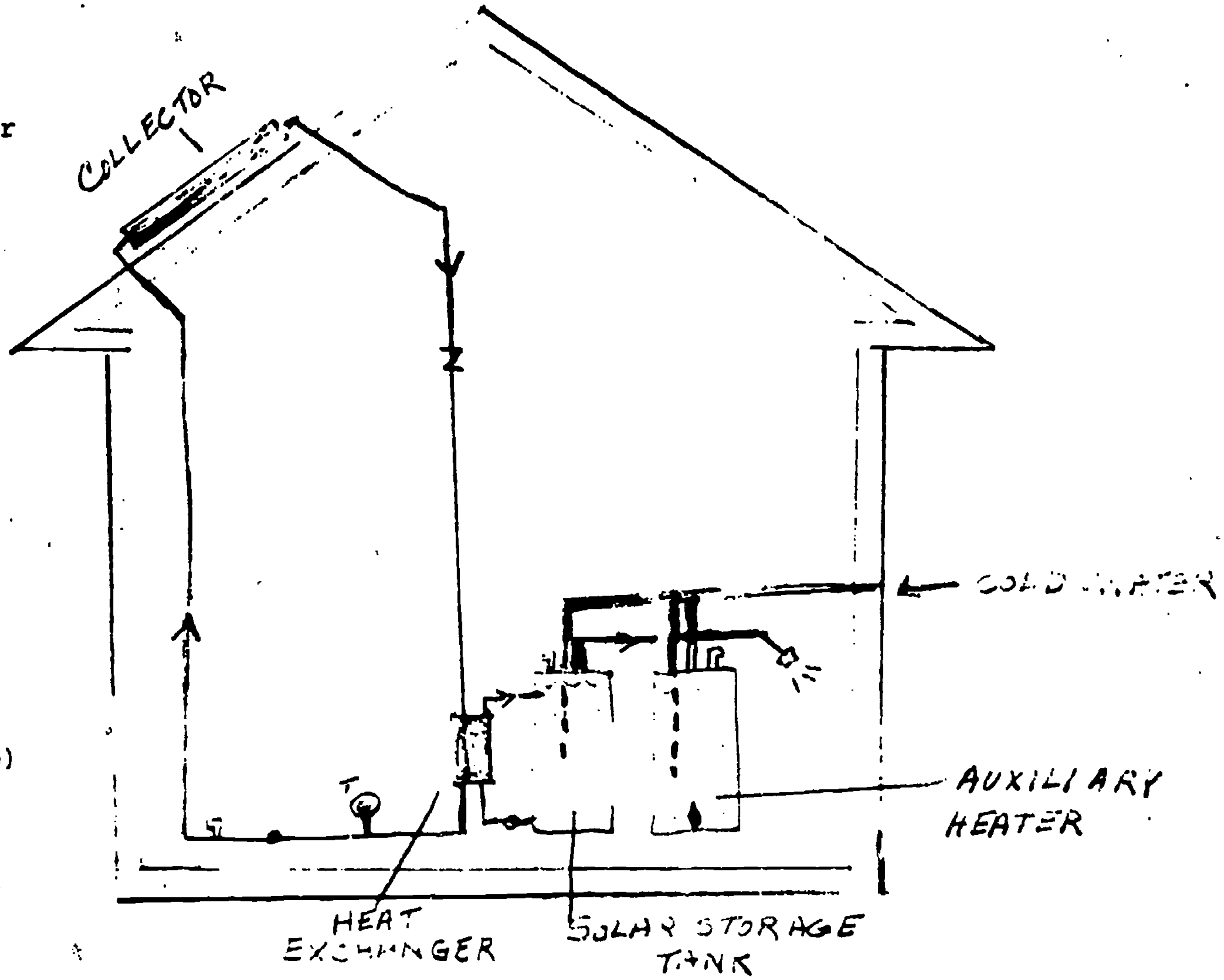
Pumped. A direct pumped system is often used when more flexibility in system layout is needed. With forced circulation, the tank need not be located above or even near the collectors. A direct pumped system typically relies on "drain-down" for protection against freezing. The pump moves water through the collectors only when there is enough solar radiation to produce useful heat. When the pump shuts off- whether by automatic control or due to power failure- the collectors are drained by gravity flow.



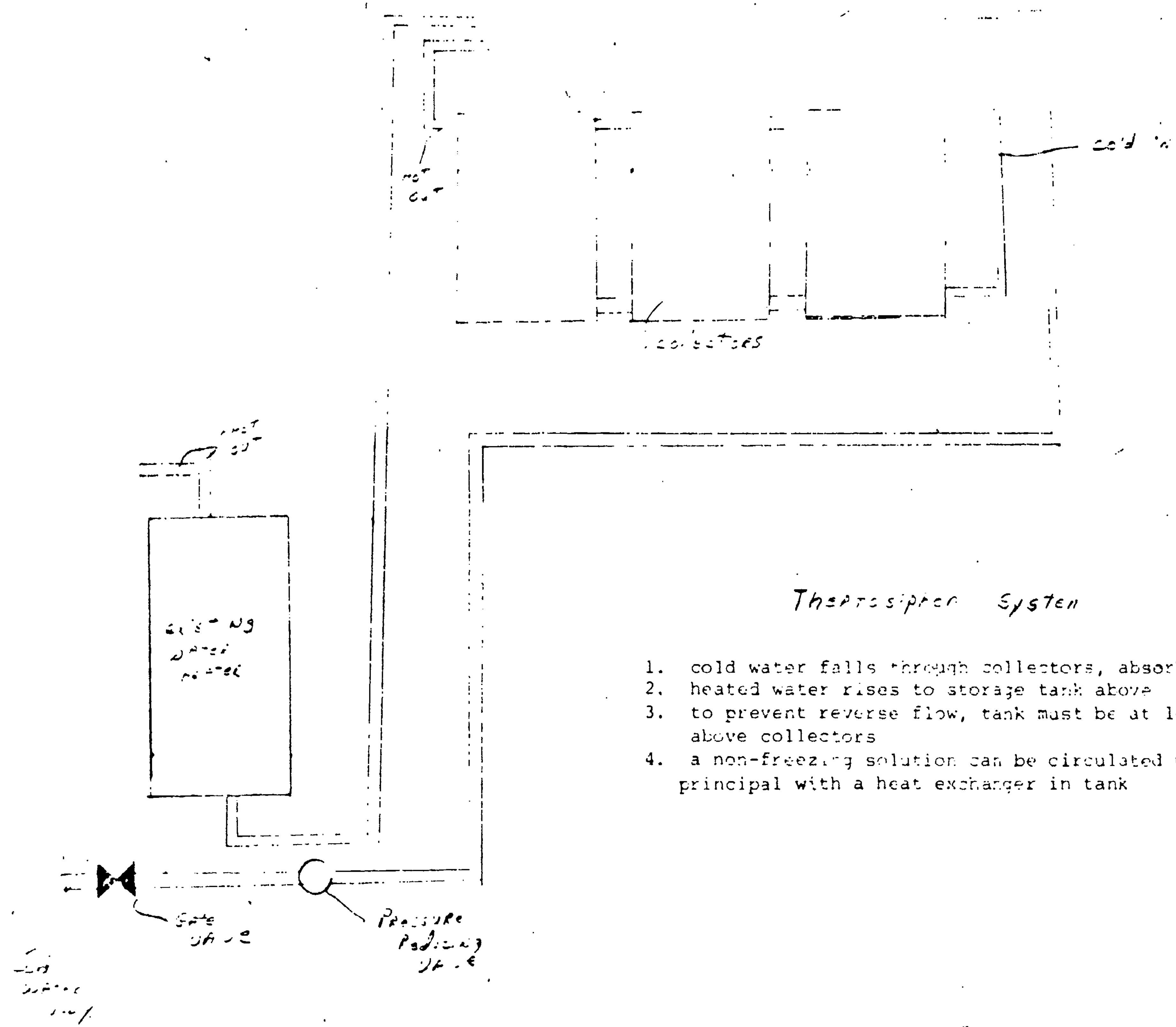
In a pumped draindown unit, solar heated water flows to the storage tank for direct use by the household. When the pump shuts off, whatever water remains in the collector drains away by gravity flow.

Indirect (Closed-Loop) Systems

The best choice for hard-water areas is an indirect, closed-loop system. The heat-transfer fluid never comes in direct contact with household water, so a corrosion-inhibiting solution can be circulated in the collector loop. Where there is a risk of freezing, an antifreeze solution or other nonfreezing fluid is often used.
In general, closed-loop systems permit the most flexible layouts and installations, but they are the more expensive to purchase and install than open-loop systems.

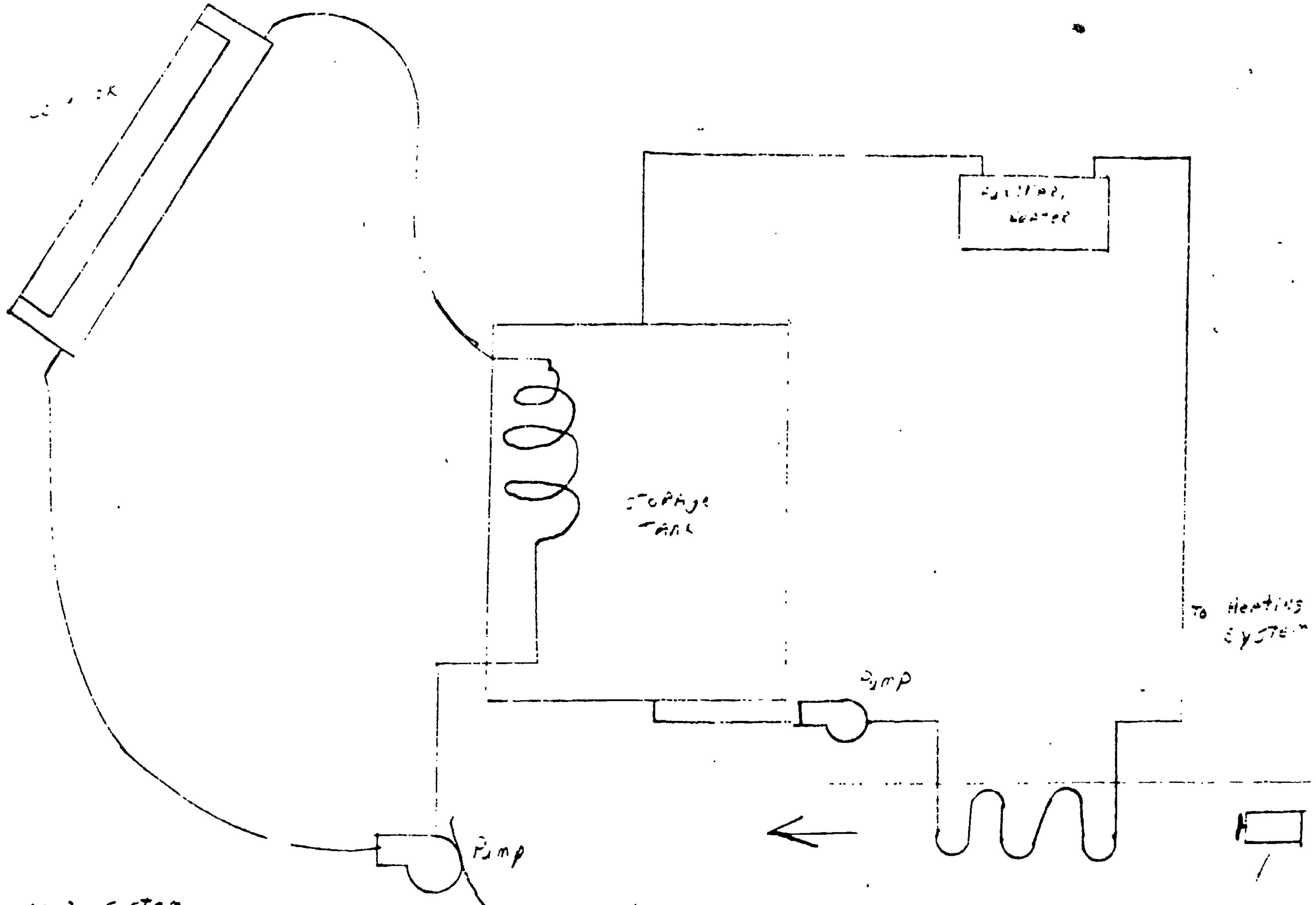


In an indirect (or closed-loop) system, an anti-freeze solution is pumped through a heat exchanger, where it gives up its heat to the house water supply.



Thermosiphon System

1. cold water falls through collectors, absorbing heat
2. heated water rises to storage tank above
3. to prevent reverse flow, tank must be at least one foot above collectors
4. a non-freezing solution can be circulated using same principal with a heat exchanger in tank



Hot water system with heat exchanger

When there is danger of freezing, a system such as this permits the use of anti-freeze liquid. The liquid is pumped through the collector and into a heat exhanger in the storage tank. There it heats the water, which circulates through the residential heating system or through another heat exchanger to transfer the liquid to an air system.

heating unit

heat exchanger. ... storage, the heat is picked up by an exchanger and run ... a coil in the air heating chamber. There a fan moves the air past the heated coil and sends warmed air into the heating system. Meanwhile, domestic water is heated by an exchanger in the storage tank. Auxiliary heat is supplie as needed.

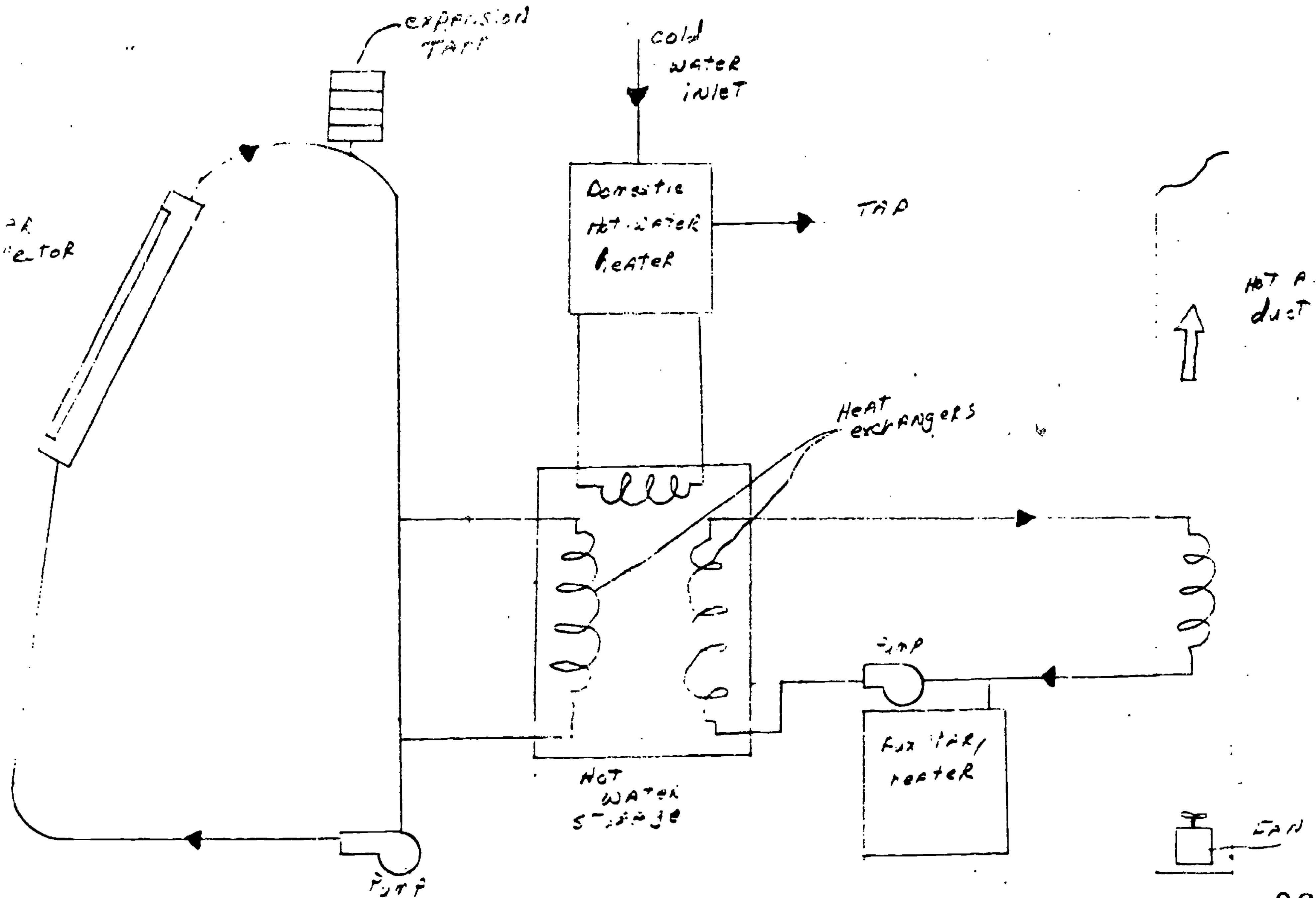
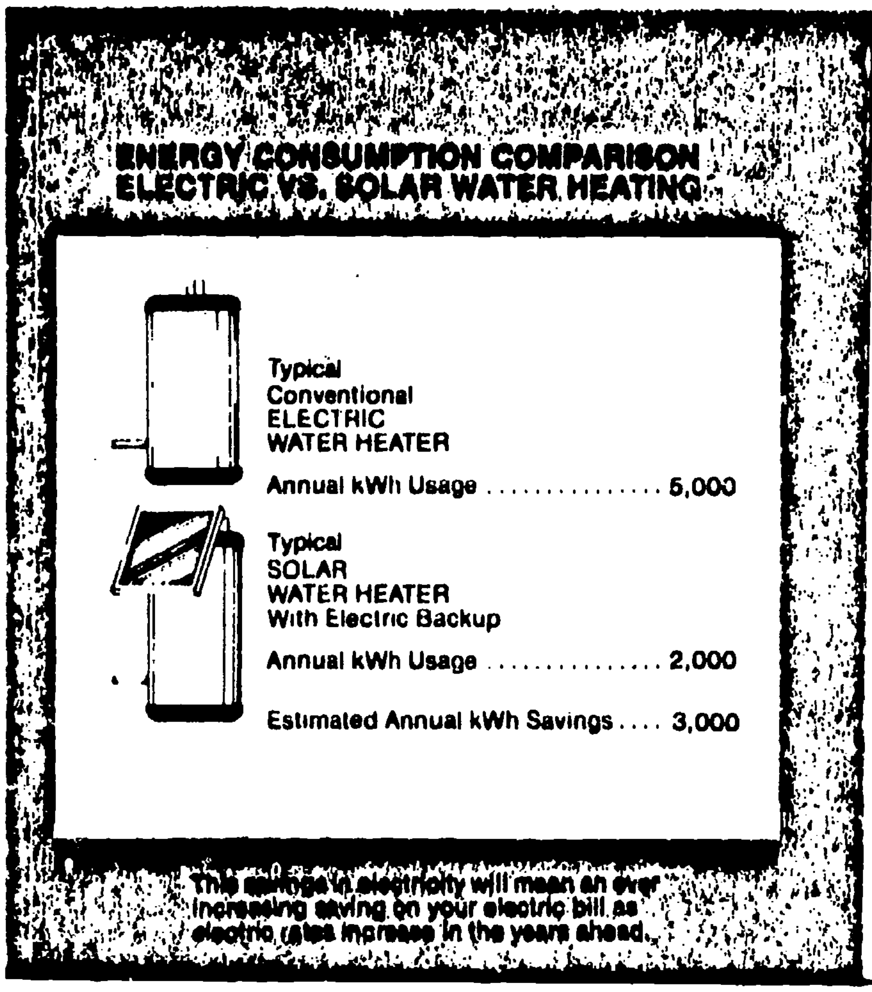


Illustration # 2


ENERGY CONSUMPTION COMPARISON
ELECTRIC VS. SOLAR WATER HEATING
Typical
Conventional
ELECTRIC
WATER HEATER
Annual kWh Usage 5,000
Typical
SOLAR
WATER HEATER
With Electric Backup
Annual kWh Usage 2,000
Estimated Annual kWh Savings 3,000
This savings in electricity will mean an ever increasing saving on your electric bill as electric rates increase in the years ahead.

Solar Installer's Checklist

New construction mounting to unfinished roof surface
Collectors mounted to sheathing or rolled roofing: always remember to:

- Be aware of flashing requirements (i.e., spacing of collectors from other roof penetrations, spacing between collectors).
- Be aware of material compatability, avoid dissimilar metals.

Plumbing connections

Plumbing details vary with manufacturers, so remember to

- Follow guidelines in installation manuals to determine necessary fittings and other supplies.
- Make proper connections and run lines to storage tank and/or heat exchanger.
- Insulate all lines—assure protection from UV degradation, and weathering.
- Install control sensor and run wire with pipe run.
- Seal feed and return penetrations with suggested material (roof flashing, silicone caulking, other roofing sealants).
- Provide any components necessary for air elimination or entry to the system.
- Try for the most direct route available with as few turns as possible.
- [illegible]—to assure proper drainage and to help air elimination.
- Support piping or ducts as per trade practices, and code requirements.
- Pipe components as directed by manufacturer's guidelines and system schematic.
- Support all components.
- Be aware of sensible installation layout to avoid interference of space.
- Be aware of ease for future maintenance.

When locating storage tank and heat exchanger always aim for closest

- Proximity to feed and return of heat transfer fluid.
- Prox[illegible] er).
- Proximity to any existing water heating equipment to be placed in series with solar water heater.

Electrical

When dete[illegible] electrical hook-up for storage tank, pump, fan, or controls (some building codes require separate circuits for powering solar system components) remember to:

- Check out controls *before* installation.
- Install controller in proximity to pump.
- Wire pump and controller.
- Wire sensors to controller (after sensors are in place).
- Wire any solenoid or control valves, or heating elements required.
- Install and wire any monitoring devices.

Installation pressure test

Install all components except those unsuitable for high pressure (air vents, expansion tanks, temperature and pressure relief valves).

- Pressure test system at 80–100 psi for one hour.

Install all components

- Pressure test system at 30 psi for 24 hours.

Check with manufacturers for test and working pressures for all components.

Discharge pressure test after satisfying requirements

- Install all missing components.
- Flush system prior to final charge, and drain to remove dirt and flux.
- Charge system with heat transfer fluid (if antifreeze, assure proper ratio for designed protection).

Pressurize to manufacturers suggested operating pressure and then remember to:

- Operate circulator (either automatically or by directly plugging pump into electrical source).
- Bleed air from venting locations as installed.
- Assure final working pressure.
- Res[illegible] all controls for automatic operation.
- Label all relevant valves with simple explanation of function and operating position (cold feed to collectors, leave open).

Basic tools and materials needed

TOOLS

Pipe wrenches (2) 14" or 18"
Sink Wrench
¾" Box or Open End Wrenches
Wire Stripper or Knife
Wire Cutters
Phillips Head Screw Driver
Regular Screw Driver
Adjustable Wrenches (2) 10"
Electric Drill w. ½" and ¾" Wood Bits
Saw

MATERIALS

Pipe Joint Compound (for galvanized, iron pipe systems)
Wire Nuts or suitable wire connectors and plastic tape
Miscellaneous pipe and fittings (copper and galvanized iron pipe systems)
Propane Torch
Solder, Flux
Emery Paper
Silicone caulk or cold roof tar
Pipe clamps or hangers (one for every three feet of pipe
Wood (2 x 6 or 2 x 8 for spreader beams inside roof)
Insulation (for all piping in Solar System)
Solar collector panel installation kit for parallel mounting or tilted mounting

Specifications

MODELS		STORAGE TANK
82 Gal.	120 Gal.	Tank Storage Capacity
9 Gal. Approx.	9 Gal. Approx	Heat Exchanger Capacity (Distilled Water)
63"	64"	Height/without Reservoir Tank
24	28"	Diameter
13¼	13¼"	Height (Reservoir Tank)
235 lbs	367 lbs	Tank Weight (Empty)
948 lbs	1367 lbs.	Tank Weight (Full)
65 lbs	65 lbs.	Reservoir Tank (Empty)
133 lbs	133 lbs.	Reservoir Tank (Full)
4500	4500	Booster Element Wattage
240 Volts	240 Volts	Booster Element Voltage
18.4 GPH	18.4 GPH	Booster Element Recovery (G.P.H. = Gallons Per Hour)
30 Amps	30 Amps	Booster Element Maximum Fuse Size
10 Ga	10 Ga.	Booster Element Minimum Wire Size*
185	185	Heat Exchanger Pump Wattage (Single)
370	370	Heat Exchanger Pump Wattage (Double)
18'	18'	Heat Exchanger Pump Maximum Head (Single)
36'	36'	Heat Exchanger Pump Maximum Head (Double)
120 Volts	120 Volts	Heat Exchanger Pump Voltage
15 Amps	15 Amps	Heat Exchanger Pump Maximum Fuse Size (Single)
15 Amps	15 Amps	Heat Exchanger Pump Maximum Fuse Size (Double)
14 Ga	14 Ga	Heat Exchanger Pump Minimum Wire Size*

	COLLECTOR PANEL (EACH)
123"	Length
51	Width
160 lbs	Weight

*Based on standard @ 60 C copper wire. If distance from fuse box to water heater is more than 90 feet, refer to your local electrical code for correct wire size

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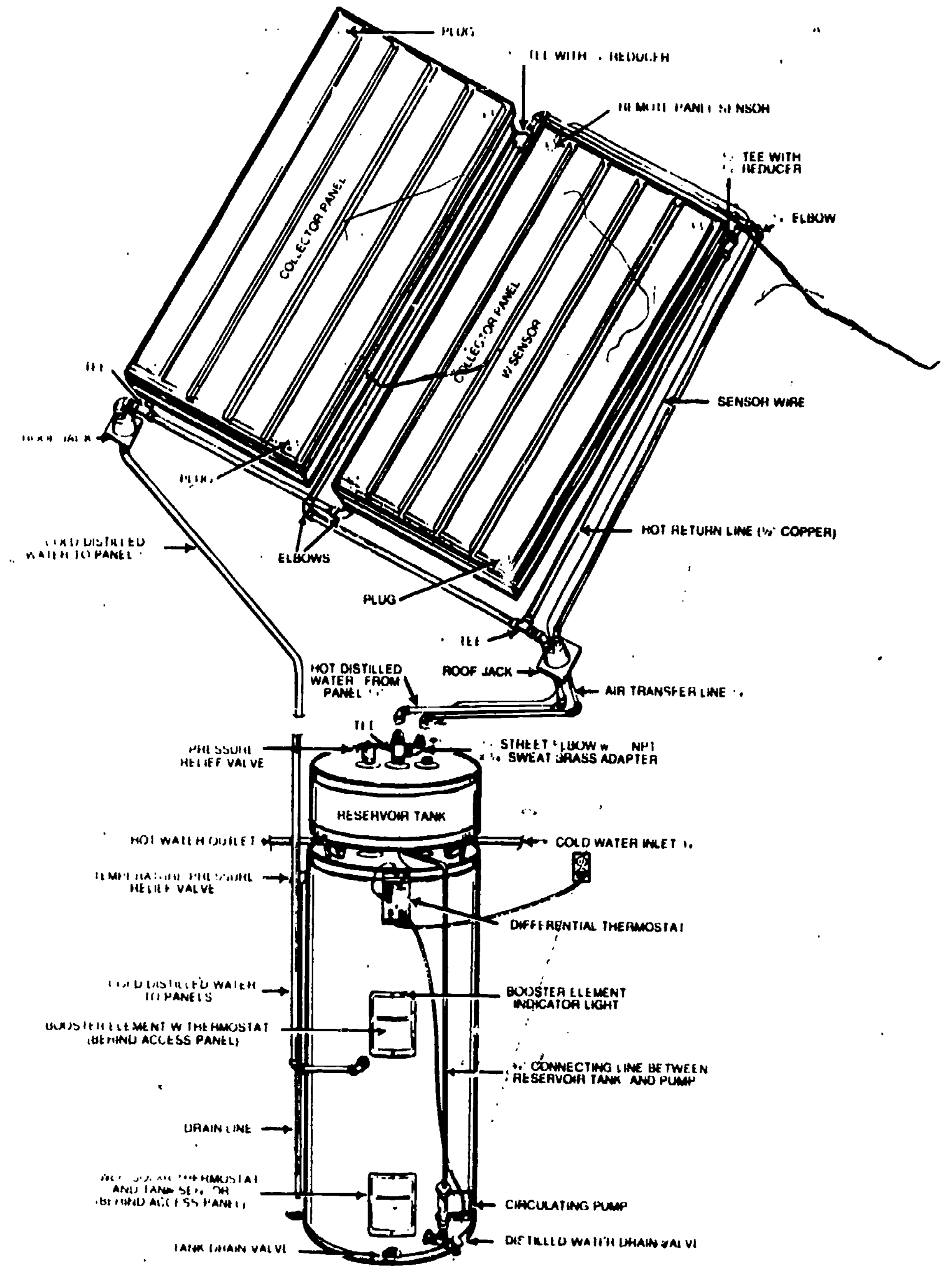
Typical Installation

The installation diagram is designed only to show location of the basic system components in an over all view. Detailed information should be taken from specific sections in this manual.

Remember: Inlet and outlet connections must be diagonally opposite corners and sensor must be on outlet end.



RESOURCE MATERIALS

U. S. Department of Housing and Urban Development,
Office of Policy Development and Research
Is Solar Water Hearing Right for You?
Washington, D. D., 1980

U. S. Department of Housing and Urban Development,
National Solar Heating and Cooling Information Center
Solar Fact Sheet
Rockville, MD 20850, May 1980

Superintendent of Documents,
U. S. Government Printing Office
Hot Water From the Sun
Stock #023-000-00620-1, $4.75
Washington, D. C. 20402

U. S. Department of Housing and Urban Development
National Solar Heating and Cooling Information Center
Solar Water Heaters
Rockville, MD 20850

Handle Films
How to Build a Solar Heater
Nashville Public Library
20 min. 1977

Tennessee Energy Authority
Here Comes the Sun
15 min. color

FOOTNOTES

1. Back to Basics, ed., The Reader's Digest Association, Inc., New York, 1981, p. 110
2. Ibid.
3. Ibid., p. 112
4. Ibid.
5. Ibid.
6. Ibid., p. 110
7. Ibid., p. 118
8. Ibid., p. 111
9. Ibid.
10. Ibid.
11. Tennessee Valley Authority, Solar Nashville TN, 1981, p. 1
12. Ibid.
13. U. S. Department of Housing and Urban Development, National Solar Heating and Cooling Information Center, Solar Fact Sheet, Rockville, MD, May 1980, p. 1
14. Department of the Treasury, Internal Revenue Service, Energy Credits for Individuals, Washington, D. C., Pub. 903, 1979, p. 1
15. Schwaller, Anthony E., Energy Technology, Sources of Power, Mass., Davis Publications, Inc., 1980, p. 185
16. Ibid.
17. Ibid., p. 186
18. Keyes, John H., Consumer Handbook of Solar Energy, New York, Morgan & Morgan, 1979, p. 6
19. Ibid., p. 17

20. U. S. Department of Housing and Development, National Solar Heating & Cooling Information Center, Solar Fact Sheet, Rockville, MD 20850, May 1980, p. 2

21. Basics, p. 118

22. Hand, Jackson, Home Guide to Solar Heating & Cooling, New York, Harper & Row, 1978, p. 83

23. Ibid., p. 84

24. Oak Ridge Associated Universities for the U. S. Department of Energy, Solar I Teachers Guide, Oak Ridge, TN Feb. 1980, Experiments #7, 8, & 11

25. Basics, p. 111

26. Fact Sheet, p. 1

27. Ibid., p. 2

28. Ibid., p. 3

29. Ibid., p. 3

30. Solar Nashville, p. 2

31. Solar Age Resource Book, ed., Solar Age Magazine, New York, Everett House, 1979, p. 73

32 Manual: Installation, Operation, Maintenance-Solar Water Heater, Solarcraft Water Heaters, State Industries, Inc.

BIBLIOGRAPHY

Back to Basics, ed., The Reader's Digest Association, Inc., New York, 1981

Schwaller, Anthony E., Energy Technology, Sources of Power, Mass., Davis Publications, Inc., 1980

Keyes, John H., Consumer Handbook of Solar Energy, New York, Morgan and Morgan, 1979

_______________, Harnessing the Sun, New York, Morgan & Morgan, 1975

Ewers, William I., Solar Energy, New York, Domus Books, 1979

Norton, Thomas W., Solar Energy Experiments, PA., Rodale Press, 1977

The Solar Age Resource Book, ed., Solar Age Magazine, New York, Everett House, 1979

Hand, Jackson, Home Guide to Solar Heating and Cooling, New York, Harper & Row, 1978

Producing Your Own Power, ed. by Carol Hupping Stoner, New York, Vintage Books, 1975

Hoke, John, Solar Energy, New York, Franklin Watts, 1978

U. S. Department of Housing & Development,
Office of Policy Development and Research,
Solar Factsheet
Washington, D. C., FS119, May 1980

Tennessee Valley Authority
Solar Nashville
Tenn, 1981

Department of the Treasury,
Internal Revenue Service
Energy Credits for Individuals
Washington, D.C., Pub. 903, 1979

Oak Ridge Associated Universities for the
U. S. Department of Energy
Solar I Teachers Guide, Experiments #7, 8, & 11
Oak Ridge, Feb. 1980

U. S. Department of Housing and Urban Development,
Office of Policy Development and Research
Is Solar Water Heating Right for You?
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